Polarized Cathode Development Update

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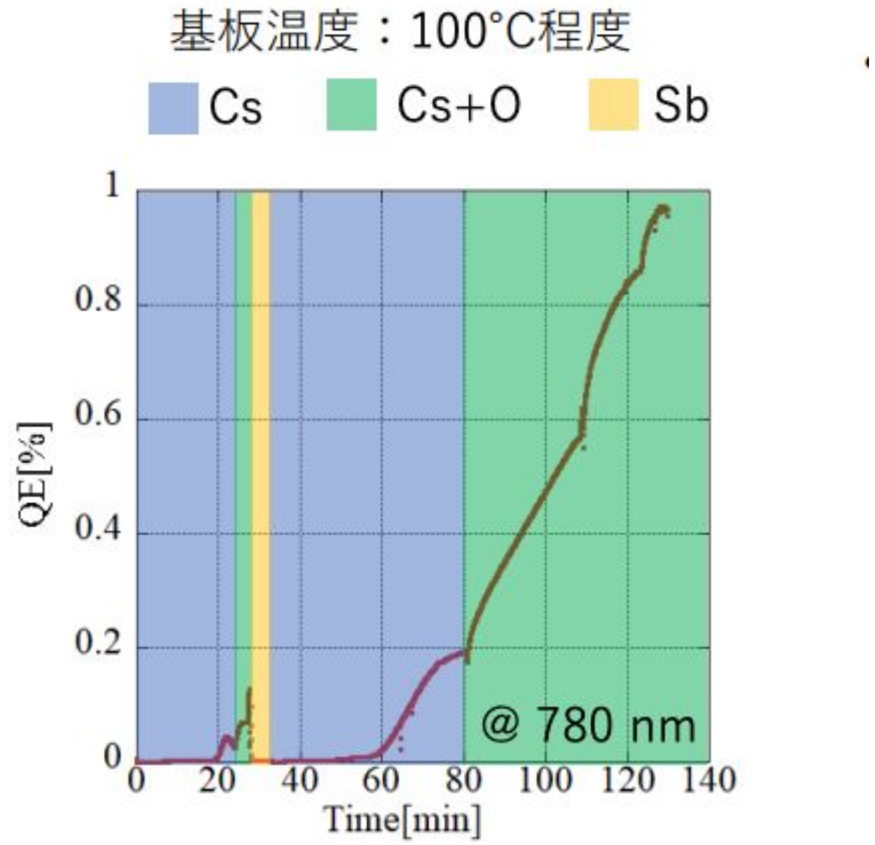
Spring 2024 Experimental Plan and Status

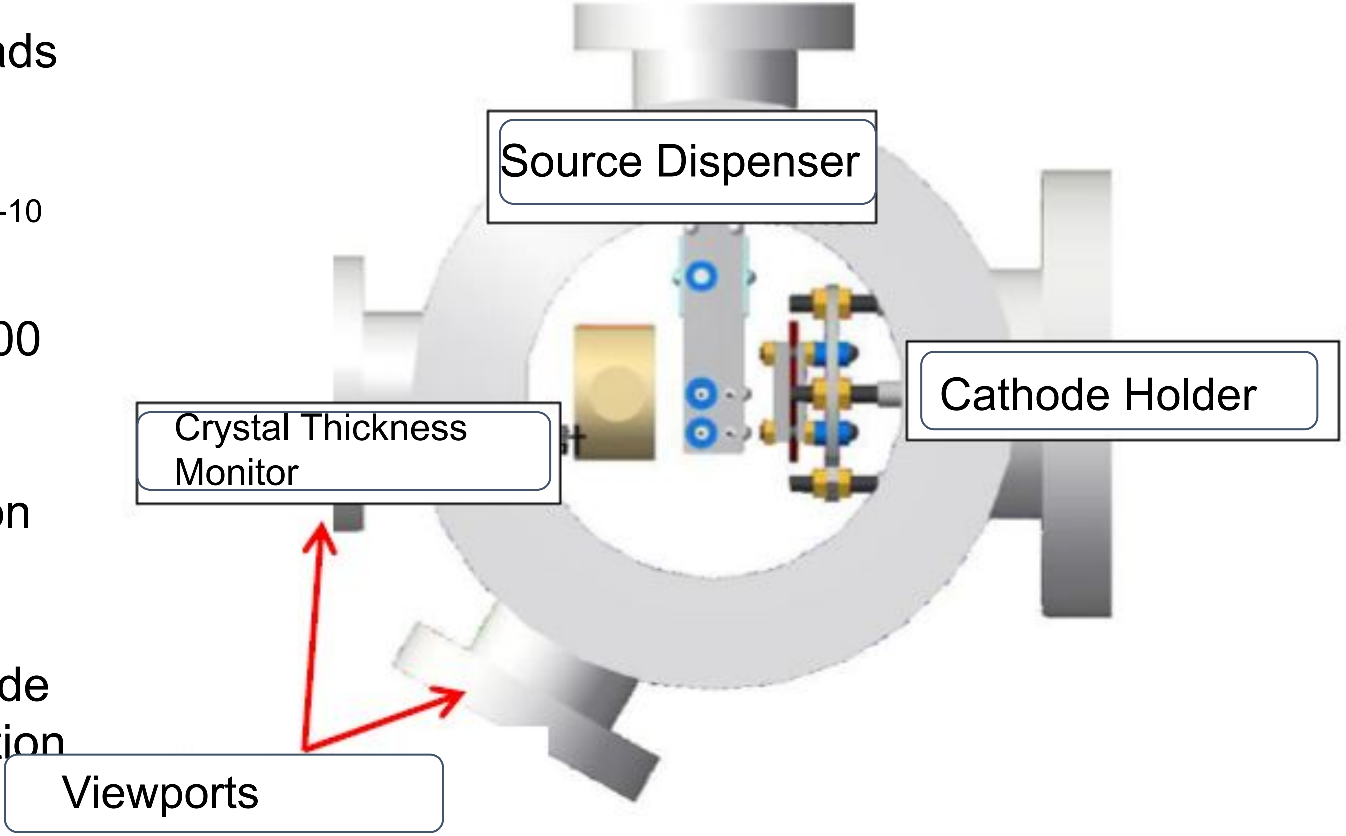
- Intended to reproduce results from Nagoya U’s late 2023/early 2024 experiment.
- They observed increased QE when applying a thin layer of Cs-CsO prior to the Sb base.
- Note: the figure at right says the cathode was held at 100º, but it was actually at room temp.



NEA(Cs+O)-GaAsと同程度のQEが達成

Reminder: Evaporative Deposition Setup and Procedure

- GaAs substrate prepared (cleaned) and affixed to holder
- Cs, K dispensers attached to holder and Sb beads placed into a conducting wire basket
- Chamber is baked, degassed, etc., to get to working vacuum environment (ideally 10^{-9} or 10^{-10} Pa)
- Voltage attached to heated cathode (~1-2 kV, 100 C) consistently
- Voltage applied to terminals for Sb, K, Cs in sequence to cause evaporation, with evaporation confirmed via rise in pressure
- Thickness measured with a thin-film monitor – piezoelectric crystal inserted opposite the cathode holder, measures deposition via changing vibration frequency of inserted crystal
- QE is measured at each step by illuminating the cathode with a Xe lamp filtered through a grating to select wavelengths from 300 - 950 nm and output current from cathode is recorded



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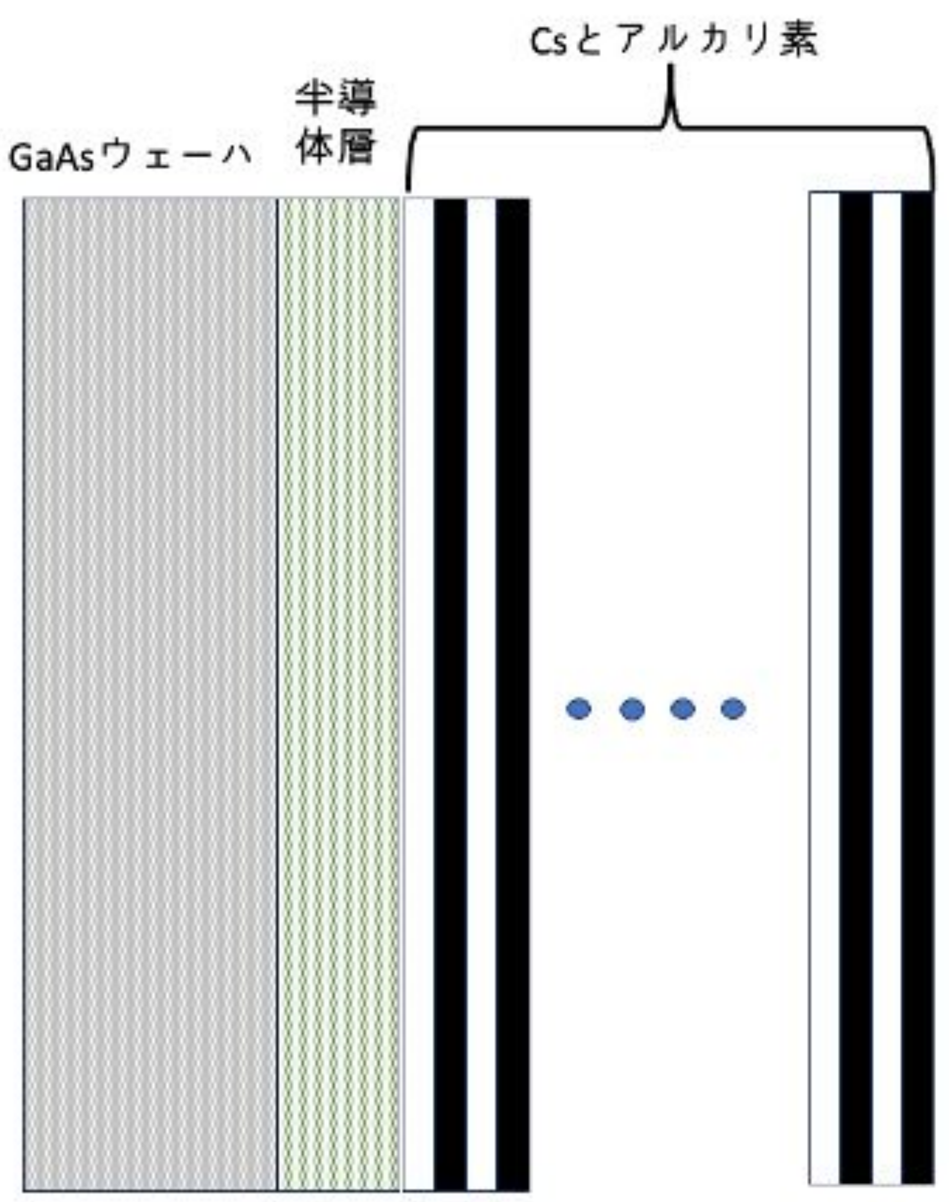


Previous Experimental Run

- First attempt at an experimental run: ended with data consistent with 0 → no conclusive evidence of cathode production
- Second run done in 2 stages:
  - 250 Å Sb + 600 Å (total) Cs + K in 50 Å layers

Wavelength (nm) / Energy (eV)	Measured QE (%)	Error (%)
350 / 3.54	1.83E-02	1.42E-03
890/1.39	-1.4E-04	1.83E-04

  - Increased K + Cs deposits to a total of 1250 Å

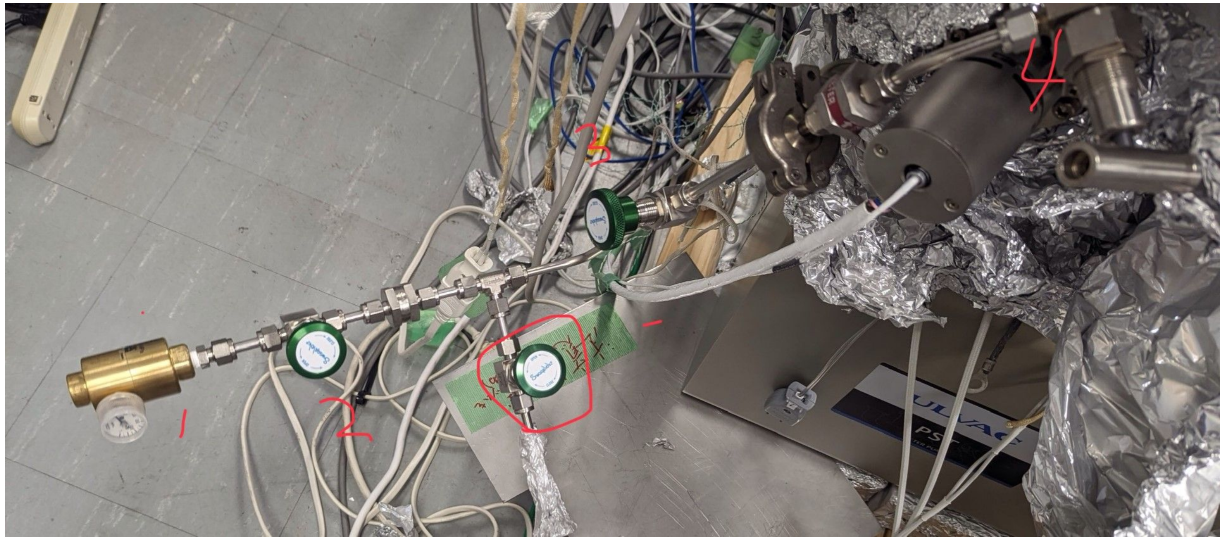
Wavelength (nm) / Energy (eV)	Measured QE (%)	Error (%)
350 / 3.54	3.44E-02	1.38E-03
890/1.39	2.16E-04	2.06E-04

- Evaporative deposition has produced a working cathode with QE around ~(3.44 ± .14) x 10^{-2} %

New Work and Updates for 2024

- After B2GM, tried over several runs to reproduce Nagoya's results with Cs-CsO-Sb (not with Cs-K-Sb as before).
- New undergrad (M. Isobe) starting April 2024 – already participating in cathode preparation and testing.
- New laser system – a ~2.5 mW laser with an adjustable mirror guide mounted directly onto the viewport rather than the Xe lamp and lens system used previously.

Several runs of cathode production were halted by the introduction of too much Oxygen into the vacuum chamber.
O2 introduction system (shown at right) is very finicky and opening the valves too far can lead to sudden overpressure in the chamber and arcing during deposition.



During the most recent test, we were able to successfully introduce pure O2 along with Cs and produce a photosignal.

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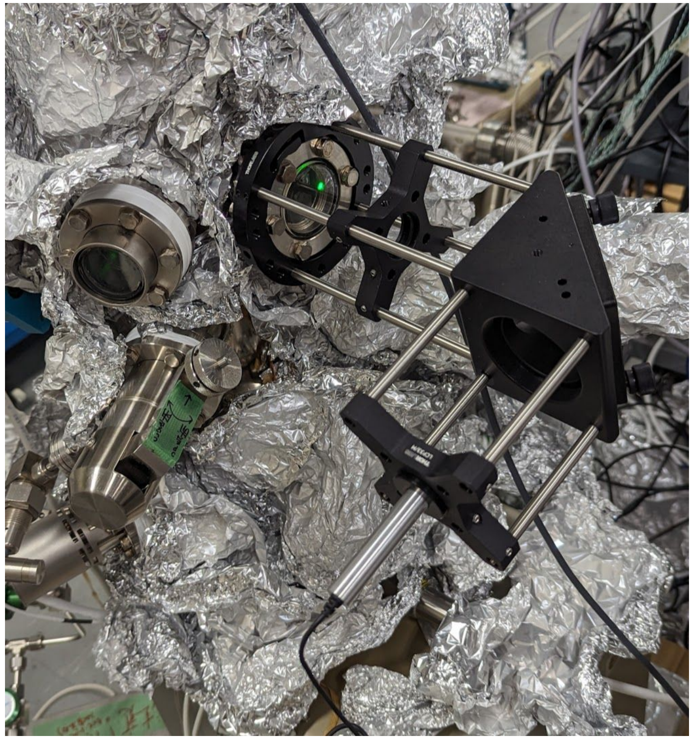
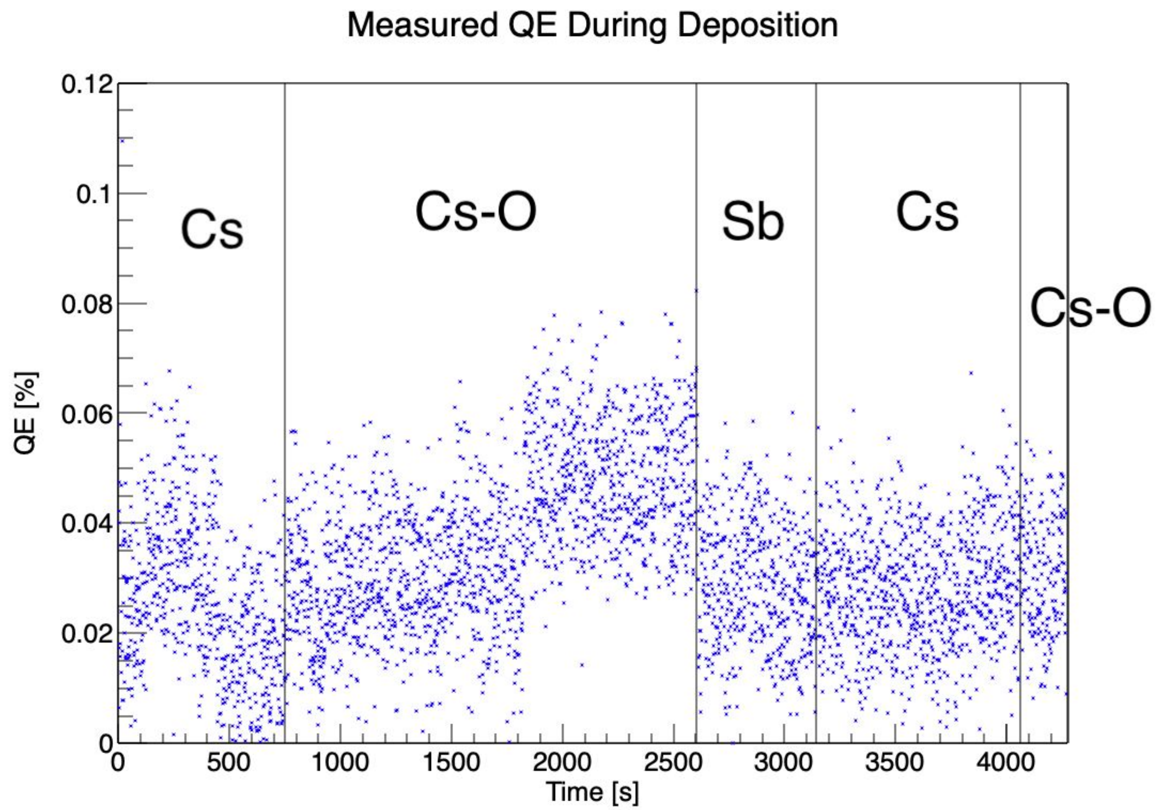


Laser mount system on the vacuum chamber viewport

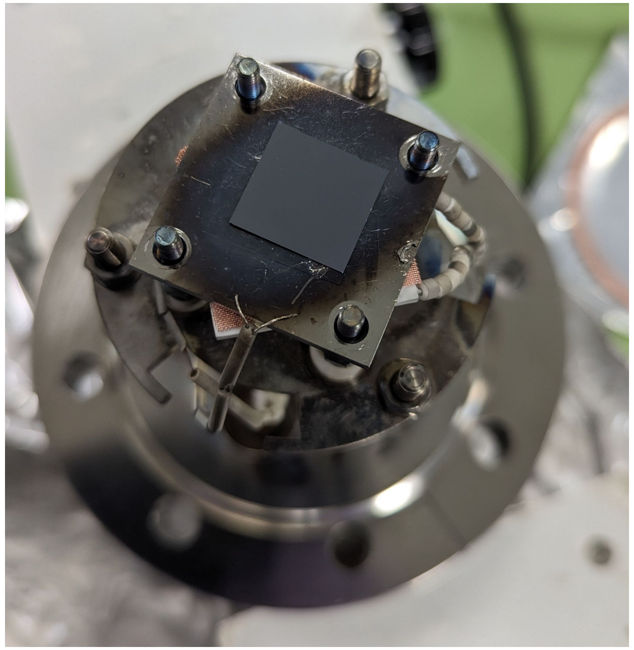
Results



Data taken during deposition periods. Each of the thin-film materials is indicated.

We observe a photosignal of < 1% during deposition of Cs and CsO prior to Sb, in agreement with Nagoya's results.

However, after Sb deposition, we did not see an indication of photocurrent in real time.
After cleaning the data, this was probably premature and we should have continued longer with CsO.



Our most recently-prepared cathode

Experimental Challenges

Working to correct some conditions in our lab to make data-taking easier:

- thin-film monitor has been unresponsive; plan to replace the crystal and move to a newer (recently-purchased) monitor if possible.
- electrical noise causes the signal from the cathode to have spikes every ~10s, making real-time QE monitoring difficult. Looking for ways to overcome this noise or isolate the system.
- The Labview control system is gradually coming out of date and needs to be updated.

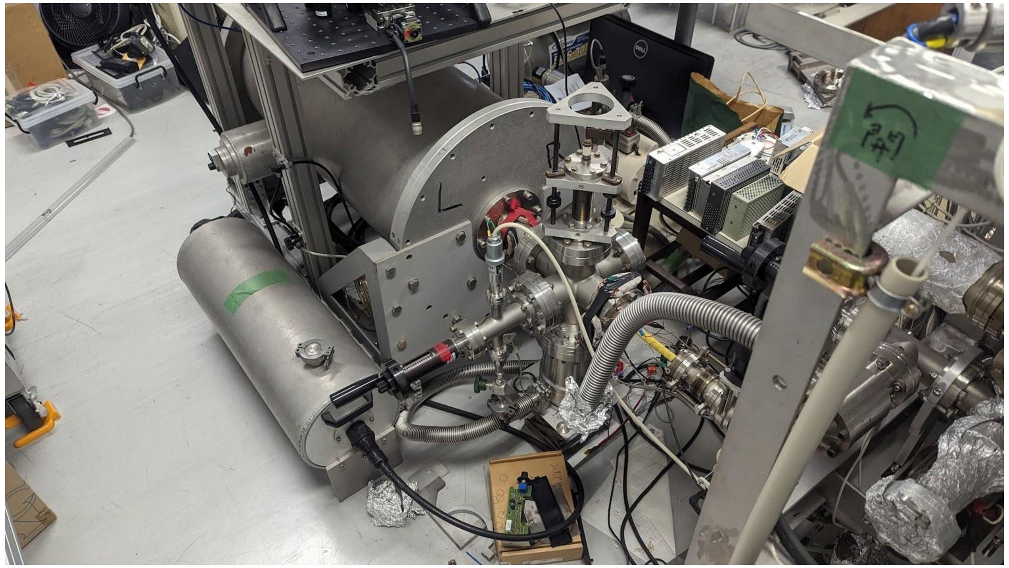
Mott Polarimeter at Nagoya

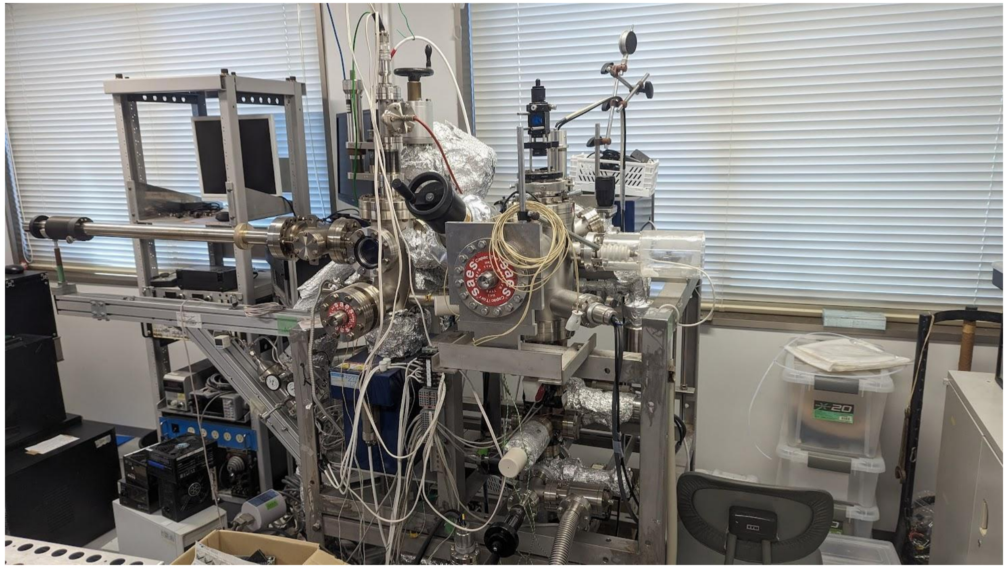
Visited Nagoya U. lab in March to look at their Mott Polarimeter.
The unit they have now is very old and hasn't been used in a long time, and would likely need a lot of work to make it usable again.

→ probably more time- and cost-effective to get a new one.

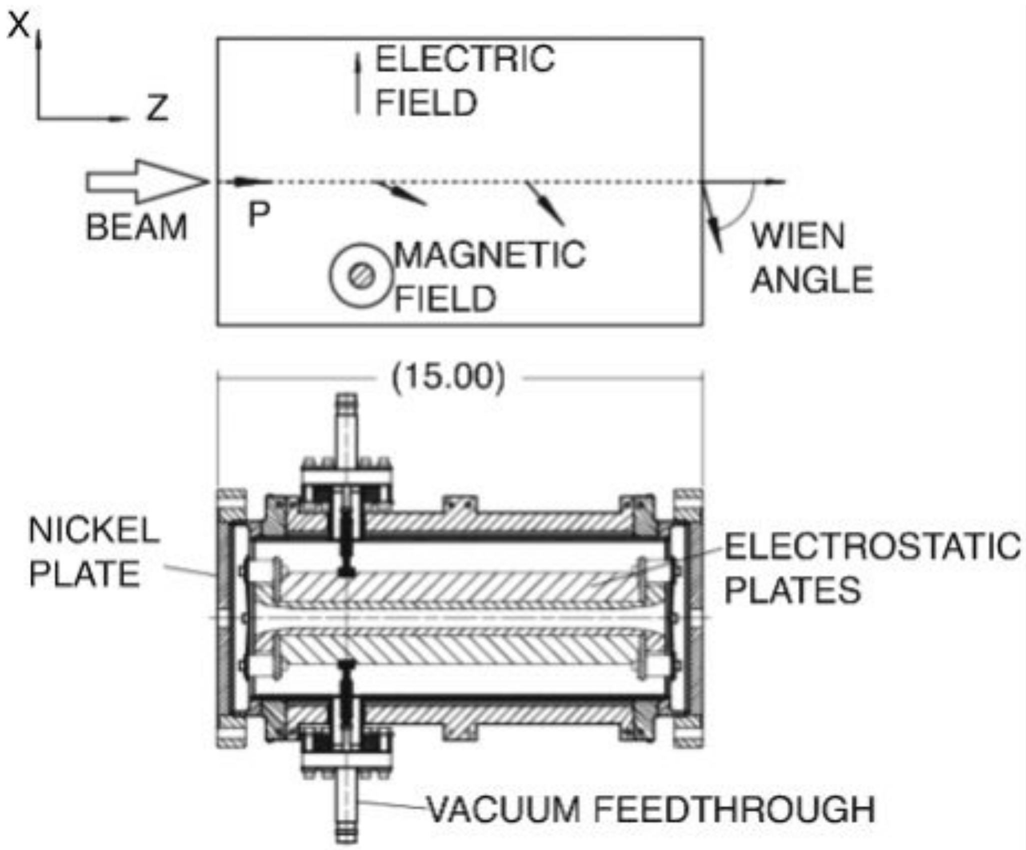
In particular, many of the necessary components were custom made and the engineer who made them has moved to a different department.

-They'll be receiving a newer polarimeter this FY which should be more usable on the timescales of our experiment.





Spin Manipulation



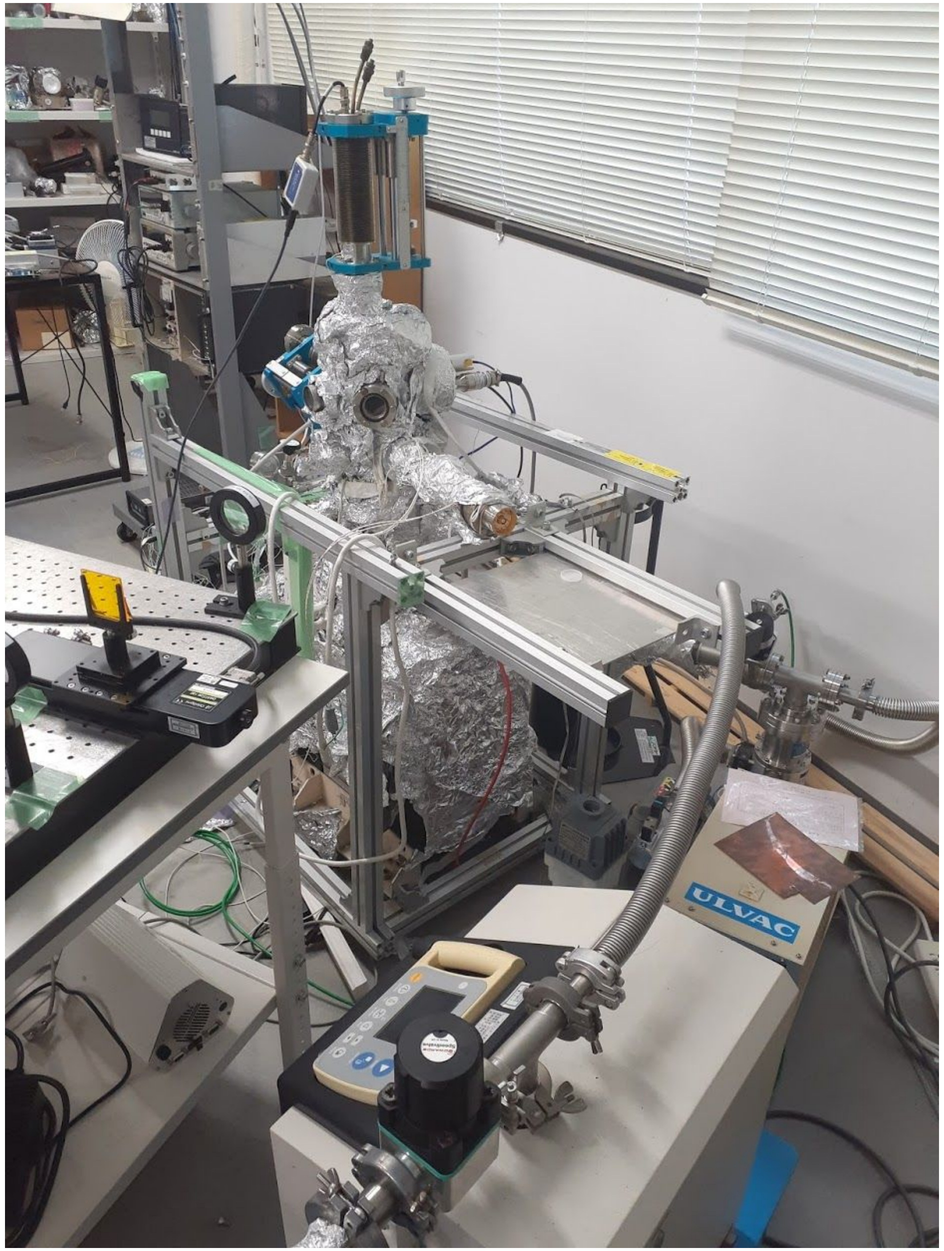
CEBAF Wien Filter detail (solenoid suppressed).

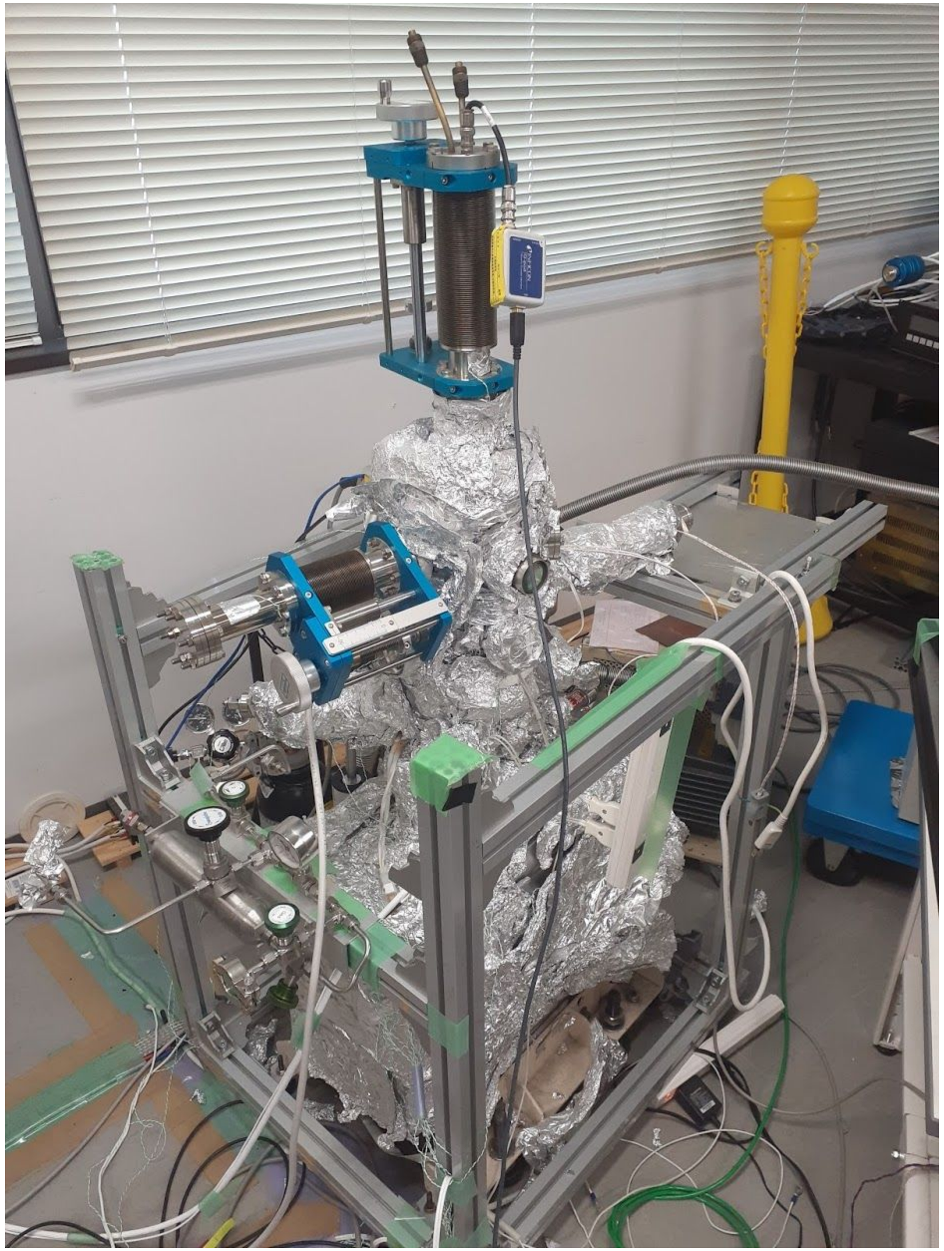
[1] J.M. Grames et al., Phys. Rev. ST Accel. Beams **7**, 042802 (2004)

For cathode sources, spin emerges (anti)parallel to the direction of travel – requires spin manipulation to align to vertical after generation.

- Details to be determined by actual setup at SKB
- Wien filter fields determined by electron energy (to satisfy $\beta c = E/B$)

Our Setup: Vacuum Chamber





Our Setup: Xenon lamp

Used for testing QE response from cathode with tunable wavelengths